



**National
Transportation
Safety Board**

Flight Test Operations and G650 Takeoff Field Performance Developmental Testing

Operations presentation

Flight Test Overview: Purposes of Flight Test

- Define aircraft operating characteristics
- Identify differences between observed and predicted system behavior
- Obtain data to support development and certification

Flight Test Overview: Phases of Flight Test

- Development
 - Conducted by manufacturer
 - No direct Federal Aviation Administration (FAA) involvement
- Certification
 - Conducted by FAA with manufacturer
 - Subject to FAA policies and oversight

Flight Test Overview: Developmental Testing

- Evaluate aircraft characteristics and performance
- Identify problem areas and make fixes
- Analyze data and document results
- Prepare for certification testing

Flight Test Overview: Certification Testing

- Obtain FAA approval for type inspection authorization
- Perform selection of tests under direct FAA supervision
- Demonstrate compliance with applicable certification regulations

Flight Test Overview: Flight Test Safety Program Requirements

- During developmental testing—at manufacturer's discretion
- During certification testing—must be consistent with guidance set forth in FAA Order 4040.26

Flight Test Overview: Flight Test Safety Program Requirements

FAA Order 4040.26

- Review test plan
- Identify hazards
- Assess risks
- Establish procedures to minimize risks
- Decide whether to accept residual risks

Gulfstream's Flight Test Risk Management Program

- Gulfstream had an FAA-accepted risk management process
- Overseen by flight test safety review board (SRB) co-chaired by director of flight test and vice president of flight operations
- SRB review and approval required before start of developmental flight testing
- Did not specify when SRB must be reconvened during developmental testing

Gulfstream's Flight Test Risk Management Program

- SRB approved risk assessment for field performance on October 7, 2010
- Findings incorporated into field performance test safety hazard analysis (TSHA) forms and flight test cards
- First field performance flight test occurred on October 19, 2010

Uncommanded Roll Events

- Two uncommanded roll events occurred before accident flight, in November 2010 and March 2011
- SRB not reconvened
- Testing should have stopped because uncommanded roll events were unexpected test result

Uncommanded Roll Events

- Flight 88, November 16, 2010: minimum unstick speed (V_{MU}) test
 - Flown by pilot-in-command (PIC) of accident flight
 - Flight crew recovered airplane
 - Testing not stopped
 - Attributed to over-rotation
 - Postaccident data review showed airplane stalled below predicted stall angle of attack



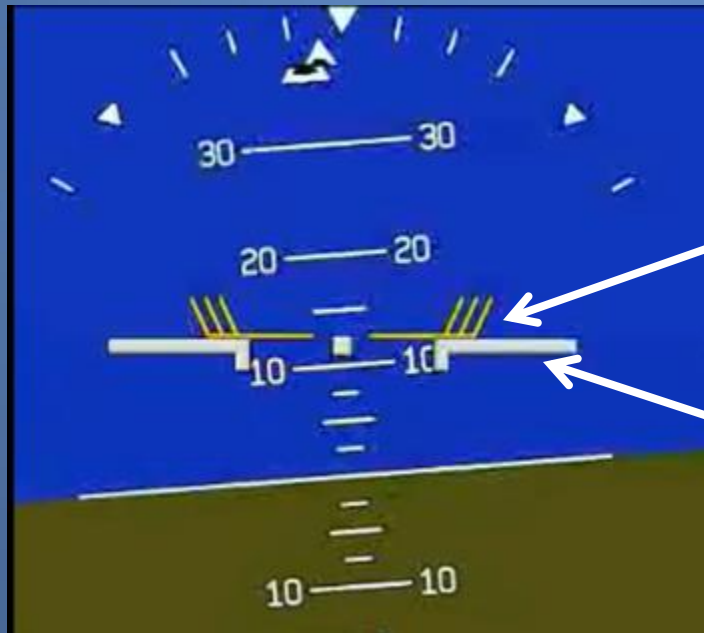
Uncommanded Roll Events

- Flight 132, March 14, 2011: flaps 20, one-engine-inoperative test
 - Flown by second-in-command of accident flight
 - Flight crew recovered airplane
 - Testing not stopped
 - Attributed to “lateral-directional” event
 - Postaccident data review showed airplane stalled below predicted stall angle of attack



Stall Warnings

Cockpit stall warnings were stick shaker and pitch limit indicator (PLI)



PLI

Aircraft
symbol

Accident Flight 153

- Preflight briefing items included
 - Target pitch lowered from 10° to 9°
 - Pitch limit of 11°
- Test card did not specify how long pitch target applied or include pitch limit
- Test personnel had different understandings of target pitch and limit

Accident Flight 153

- Accident occurred on the 12th test run, which was flaps 10 one-engine-inoperative continued takeoff
- During previous 11 test runs, all target V_2 speeds were exceeded
- Takeoff rotation technique evolved to a continuously increasing pitch angle

Accident Flight 153

- No pause at 9° pitch target, and pitch rate slowed through 9°
- Slight roll to right began 2 seconds before liftoff
- Airplane stalled below predicted stall AOA and stick shaker activation setting
- Pilots had no warning before stall

Accident Flight 153

- PIC decreased pitch below stick shaker/PLI and applied corrective roll inputs
- Airplane remained stalled
- Stick shaker activated again, and PIC increased pitch and maintained full left control wheel and rudder
- Flight crew was unable to recover from stall or control right rolling moment



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